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FINAL REPORT

Project title:
A study of the heat processing of meats with special reference to the protective effect of fat on the heat-lability of microorganisms, to obtain informations for use in producing improved canned meat products.

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Content

Summary

The purpose of the investigations was to find substances that are able to reduce heat resistance of microorganisms. Test organisms used were Sc.faecium, Staph.aureus SG 511, B.subtilis and B.stearothermophilus. Temperatures of exposure ranged from 50°C to 70°C for non-sporulating germs, and from 80° to 90°C for spores. Media used for heat-processing were glucose broth, emulsions and meat-fat-water mixtures.

A total of 147 substances of which 45 produced more or less marked reduction of heat-resistance of Sc.faecium were tested in glucose broth. A number of these substances not only reduced thermal resistance, but acted as inhibitors. The effects of other substances mainly were based upon reduction of pH. Of the substances which cannot be classified as inhibitors at the concentrations used, and whose effect was not mainly based on reduction of pH, 5-Diazo-uracil was most powerful. Satisfactory effects upon Sc.faecium in glucose broth were also obtained with Nordihydro-guaiaretic acid, Lauryl gallat, Propyl gallat, Lysozyme, Sodium pyrophosphate, and Sodium lauryl sulfate. Combining effective substances resulted in increased efficiency in part of experiments. Part of these were also effective against Staph. aureus SG 511 and spores of B.subtilis. Propyl gallat, Sodium lauryl sulfate, Sodium pyrophosphate and Lysozyme showed good-to-fair effect in emulsions. 5-Diazo-uracil was highly effective against Sc.faecium in meat-fat-water mixture, which was similar in composition to Frankfurt-style sausage. Even at 5 ppm this substance reduced D-values by 50 - 60 %. Lysozyme, Nordihydroguaiaretic acid, Sodium pyrophosphate, Glucono-delta-lactone and EDTA also showed satisfactory

efficiency. The two last-mentioned substances did not reduce thermal resistance, but inhibited germination of spores and growth of test organisms. Sodium pyrophosphate also produced the same effect, but in addition it reduced thermal resistance of test organisms.

The above results indicate that a number of substances may be suited for use in the manufacture of heat-processed meat products on the ground of their ability to reduce thermal resistance of microorganisms. This mainly applies to pasteurized meat products. Yet, use of these substances may also prove of advantage in stabilization of canned food material. Detailed studies are still requiered to clear toxicological problems possibly associated with use of several substances.

By separate investigations it should be cleared whether several of these substances, can be used alone or in combination in lieu of nitrite to destroy or suppress growth of dangerous microorganisms such as Cl.botulinum, since nitrite appears to be associated with hygienic risks owing to the possible formation of cancerogenic nitrosoamines.

I. Introduction

Heretofore general trends in food canning industry have been to improve physical and technical conditions. Now it appears unlikely that essential progress in this field can still be made, and the spoilage rate of 1-5 cans per 10.000 which can be attained with appropriate heat processing, consequently represents the absolute minimum level. With regard to the annual output of canned meat in the United States of America which in 1969 reached some 2 billions cans, this means a loss ranging from 200.000 to 1 million cans, every year.

Preservation of food products by heat also has an important role in the manufacture of meat products as a whole. As a result of the invention of new package material, especially steam- and gaz-proof and heat resistant foils, meat products which previously have been liable to spoilage, can be processed so as to be apt for prolonged storage. Length of storability of these products is judged, as a rule, to be longer than it is, by the consumers, and not infrequently by the manufacturers themselves. In consequence of this, spoilage relatively often occurs as a result of unduely long, or inadequate, storage, and this in turn rises additional hygienic problems.

Among others, success of heat processing of canned foods depends upon the state of heat resistance of the microorganisms present in the canned food material. From this it appears that an advance in food canning technology can also be made by adopting

means ensuring an artificial reduction of thermal resistance of food spoiling microorganisms. With this in view, the purpose of this research project was to find substances, which are able to reduce thermal resistance of microorganisms by direct or indirect action. In addition, rate of heat ransfer in emulsions was studied with particular reference to the effect of the type of emulsifier and fat used.

Many factors may influence thermal resistance of microorganisms. The effects which water may produce in this respect are of major importance. During the process of drying there is a rise in thermal resistance (1, 18, 44, 47, 58, 62, 64). Loss of water as a result of a change in osmotic conditions is also accompanied by an increase in heat resistance (6, 20, 45). The amount of water which is available for the microorganisms is of particular importance in this case; it is practically proportional to the water activity (a_w-value). Thus, heat resistance of a microbial species decreases with growing water activity and viceversa.

The pH of the medium also has an important influence (4, 14, 16, 19, 33, 44, 47, 62, 64, 70). Many microbial species show maximum heat resistance at pH 6-8, i.e. within a pH range present in a large number of foods, especially meat products. In addition to pH the type of acid used is also of importance. Mineral acids are said to reduce heat resistance of microorganisms to a larger extent than do organic acids at the same pH levels (16, 18, 47, 68).

Another factor which plays an important role in food preservation is the effect of salts (3, 7, 14, 16, 18, 19, 23, 26, 27, 28, 35, 47, 48, 68, 71, 72). The effects of salt ions are varying, i.e. they may reduce or increase heat resistance, or may have no effect at all. In many cases it is the concentration of salts which is of essential influence. Changes of heat resistance which are caused by salt ions largely depend upon whether the ions cause swelling or shrinkage of the bacterial cell (16, 17, 18, 26, 27, 47, 52, 58, 71, 72).

Swelling promoting electrolytes tend to lessen heat resistance, whereas it is increased by shrinkage-promoting ones. Monovalent cations mostly produce swelling and consequently act as reducents of heat resistance; divalent cations, especially Mg^{++} and Ca^{++}, withdraw water from bacterial protein and thus increase the degree of thermal resistance. Thimann (66) and Sugijama (63), demonstrated that lack of Ca, Mg, and Fe ions leads to a decrease of heat resistance of spores. Reduction of heat resistance of various microorganisms in presence of phosphate preparations, a phenomenon which has been repeatedly observed (26, 27, 28, 35, 54, 71, 72), may be due to the fact that ions of earth metals are bound by the phosphates, which in turn may lead to increased swelling of bacterial cells. Wirz (71) presented experimental evidence that swelling of bacterial protoplasm occurs in a medium containing phosphates.

In general, some salts, e.g. nitrite, produce an inhibition of certain microorganisms (8, 12, 15, 22, 46, 49, 50, 51,57, 59, 61, 65). However, views are not unanimous as to whether nitrite has specific effects upon heat resistance (40, 67).

It is generally admitted that proteins are able to increase resistance to a certain degree (1, 53, 55). However, views are still controversial on this point (47, 71).

On the other hand, it appears well established that fats and oils have a protective effect. Yet this effect is not due to a change of heat resistance, but rather to the slower rate of heat transfer in these substances. Another contributing factor is the hydrophobic structure of fats and oils, which favors the development of interfacial conditions that may affect rate of heat transfer (2, 5, 52, 58, 60, 73). The length of time required to kill germs inoculated into fat may be many times as great as that needed to kill bacteria suspended in an aqueous medium. This probably is the reason why sporulating, or even non sporulating, organisms are occasionally recovered from cans which have been properly heat-processed. In addition to insulating and hydrophobic properties of fat, free fatty acids and mono- and diglycerides as well also may have indirect effects upon heat resistance. These substances tend to lessen interfacial tension between fat and aqueous phase and thus promote penetration of microorganisms into the fat (41). Mechanical emulsification of fats also has a similar effect (73). In many foods, especially meat products, fat is present in emulsified form, and as a result of this, it is of particular interest to study the behaviour of microorganisms in emulsions. Another factor involved is the rate of heat transfer in emulsions; it appears likely that owing to the frequent interchange of fatty and aqueous phases, rate of heat penetration is varying from that observed in pure fat.

Among the substances which tend to increase heat resistance of microorganisms there are so-called protective agents the nature of which is not fully understood and which are believed to be bacterial cell products (30, 44, 69). These agents can be recovered from microbial cultures, and when added to other cultures, they may produce there a significant increase in heat resistance.

Heat resistance of microorganisms also is affected by age and functional state of bacterial cells. During the stationary phase cells are much more resistant than in the period of exponential growth. From this it appears, that young cells are more susceptible than old ones (1, 44, 56). As to spores, views are still diverging, though a large number of investigations have been made to solve this problem (62).

A phenomenon which is also of major importance in canned food production, is lagging of vegetative germs and spores after heat processing. Owing to the effect of heat, the microorganisms apparently are not able to multiply or germinate in the heat processed material, while they may regain full reproductive power in a nutritive medium presenting optimal conditions, and at optimal temperatures. The lag phase is characterized by a decrease of respiratory activity of bacterial cells. It is suggested that lagging is caused by impairment of part of the enzymatic system, and on the other hand by toxic intermediary products.

With a view to increasing the efficiency of heat-processing a large number of workers have tried to reduce heat resistance of microorganisms by addition

of certain substances. The effects which some salts have on heat resistance of microorganisms present in canned foods were described by Bergmann and Seidl (7), Kelch and Bühlmann (26), Kotter and Terplan (28), Ruf (54), Wirz (71), and Manderscheid (35). Michener et al. (40) screened 450 non antibiotic substances to test their efficiency in reducing thermal resistance of microorganisms, and detected a number of fairly effective substances.

A great variety of antibiotics also were tested in experiments designed to detect agents apt to reduce thermal resistance of microorganisms in foods. These investigations were conducted by Lewis et al. (34), O'Brien et al. (42, 43), Andersen and Michener (2), Michener (39), Michener, Thompson and Lewis (40), Denny and Bohrer (13), Honnie (24), Le Blanc et al. (31), Burroughs and Wheaton (9), and Campbell and O'Brien (10).

In the search of substances which are able to lessen thermal resistance of microorganisms, attention was also given to amino acids, because a number of these acids and their derivatives have shown inhibitory effect upon bacteria. Castellani (11) reported inhibition of microorgansims by Thioglycolic acid, DL-Serine, L-Cysteine, and Glycocoll. Giesbrecht (21) observed inhibition of the synthesis of the bacterial cell wall after treatment with D-Cycloserine, and formation of the spheroplasts following addition of Glycocoll and D-Amino acids, and of p-1-4-Acetylglucoseamidases (e.g. Lysozyme) as well.

Iwainsky and Sehrt (25) demonstrated that α-Aminobutyric acid was able to inhibit metabolic functions of Mycobacterium smegmatis, While the isomere, α-Aminoisobutyric acid tended to increase growth rate of the germ.

EDTA (Ethylene-dinitrilo-tetra-acetic acid) whose sodium salt is used in meat preservation, should also be mentioned here (32, 38). Matynia et al. (37) obtained better keeping quality of frozen-dried broiler meat, when the sodium salt of EDTA had been added to the water used for precooking the meat. EDTA proved non toxic in feeding trials on rats (29, 36).

II. Studies on the effects of various substances on thermal resistance of microorganisms

1. Experiments with vegetative germs and spores in glucose broth

1.1 Material and methods

The test organisms used were Sc. faecium and, in a few trials, Staph. aureus SG 511 and spores of B. subtilis (Difco) and B. stearothermophilus (Oxoid). Prior to heat processing the vegetative stages of test organisms were cultured in glucose broth with bromcresol purple added as an indicator. The nutritive medium used for the spores was dextrose tryptone broth (CM 73 Oxoid). Test cultures were added to the broth at a rate of 10^3-10^7/ml. Initial bacterial counts were made with the pour-plate method (see below). Test substances were added to one portion of broth culture, the other portion served as control. For part of experiments the thermal death time tube method was used. For this purpose 2 ml portions of each treated, and untreated samples were tubed in slender pyrex vials and then the vials sealed in the flame. The substances used were also assayed in test tube broth cultures, each containing 3 ml broth. Heating of both, sealed vials and test tubes, was done in a shaker water bath. The rise in temperature was controled by a thermocouple.

The moment when the test temperature was reached was taken as zero point of time of exposure. Tube cultures were prepared in triplicate to quintuple; results obtained are average values calculated from multiple data assessments. Viable counts were made on pour-plate cultures in caseine-peptone-yeast-extract-dextrose-agar ("Plate Count Agar" CM 325 Oxoid), immediately after cooling. Plate cultures were incubated at 37°C for 24 hours, and subsequently at 20°C for the same length of time. Cultures containing B.stearothermophilus were incubated at 56°C for two days. In part of experiments test tubes filled with preheated glucose broth also were incubated and regularly examined for bacterial growth. A total of 147 substances were tested (table 1). It was not uncommon for various substances to be used in varying concentrations or combinations.

1.2 Results

1.21 Reduction of thermal resistance of Sc.faecium

Of the substances tested 45 produced more or less marked reduction of thermal resistance of Sc.faecium in glucose broth (see Table 2). Of course, part of these substances not only are able to reduce thermal resistance of the test organism but act as true inhibitors[+]). Among the substances which did not prove to be inhibitors at the concentrations used, and whose effect is not, or not in first line, due to a decrease of pH of the medium, 5-Diazouracil (2/16.) was most effective.

[+]) By inhibitors we mean substances which inhibited or killed test organisms in non-heated cultures without producing appreciable decrease of pH.

The use of 100 ppm resulted in a D-value reduction (DVR) of 99 %; with 10 ppm DVR was still very high, i.e. 84 %. At higher temperatures DVR was lower, because at these temperatures D-values were much lower in controls, too. However they still reached relatively high levels, namely 67 % at 65°C (10 ppm) and 72 % at 68°C (50ppm). High DVR's were also observed when following substances were used: 1 % Ethyl valerate (2/19.) 93 % at 60°C; 100 ppm Nordihydroguaiaretic acid (2/35.) 95 % at 60°C; 200 ppm Lauryl gallate (2/31.) 71 % at 55°C; 500 ppm Propyl gallate (2/39.) 80 % at 55°C; and 500 ppm Lysozyme (2/32.) 66 % at 55°C. Rise of temperature was accompanied by a relatively pronounced decrease in the effect of Lysozyme, which is indicative of an inactivation of this substance as a result of heat exposure.

Satisfactory DVR was also obtained with Methylvanillate (2/34.), Sodium metaphosphate (2/43.), Sodium pyrophosphate (2/44.), DL-2-Acetamido-3-methylbutyric acid (2/5.), N-Hippuroyl-DL-phenylalanine (2/27.), and 3-(p-Hydroxyphenyl)-D-alanine (2/28.) (DVR 29 - 62 %).

With respect to the substances which are able to lower the pH of a medium, it is worth noting that the reduction of pH primarily is responsible for the reduction of D-values, though there is no significant relation between the pH of the medium and DVR. The correlation coefficient of r =-0,20 is rather low and does not significantly differ from zero. From this it appears that part of these substances have a specific effect upon thermal resistance of the test organism, while others, though producing a more marked reduction of pH, resulted in a relatively lower DVR. Hexanoic acid (2/24.) gave a DVR of 96 %

at pH 5,7 and holds a place in the first group. Marked decrease of pH and relatively low reduction of D-values was obtained with the following substances: 2-Acetamido-4-(methylthio)-butyric acid (2/6.) DVR 38 % at pH 5,0; DL-Aminosuccinic acid (2/11.) DVR 38 % at pH 5,4.

Among the substances which acted as inhibitors Sodium lauryl sulfate (2/42.) deserves particular attention. At a concentration of 100 ppm the substance was highly effective at 55°C and 60°C (DVR 98 % and 88 %). It appears worth noting that the substance was significantly less effective at 50°C, at which temperature DVR was 60 % only. This suggests that Sodium lauryl sulfate has not only an inhibitory effect, but specifically reduces thermal resistance of the test organism. A concentration of 10 ppm still results in a DVR of about 30%.

Some substances which gave positive results when used alone were also used in combination with other substances to examine whether summation or syergism occurred. Results are listed in table 3. With regard to the concentrations used, 0,2 % Sodium pyrophosphate plus 0,01 % Lauryl gallate (3/1.) gave some increase in efficiency at 55° and 60°C, while a significant increase was noted at 50°C. When Sodium lauryl sulfate was used in combination with either Lauryl gallate (3/8.) or Propyl gallate (3/9.) or curing salt (NaCl + 0, 6 % Sodium nitrite) (3/10) there was significant summation of effects, especially at lower concentrations. The combination of GdL (Glucono-delta-lactone) and Ascorbic acid (3/14.) also gave a marked rise in efficiency. Other combinations showed no, or only insignificant, increase in efficiency.

1.22 Reduction of thermal resistance of Staph. aureus SG 511

Only part of the substances used in the investigations were tested on Staph. aureus SG 511, because this germ, owing to its high heat sensitivity, was not a good test organism. It is, however, wath noting that final results were not analogous in all cases to those abtained with Sc.faecium. Results are summarized in table 4. Lysozyme (4/1.) was nearly ineffective against Staph.aureus. Similarly, Lauryl sulfate (4/2.) and Sodium metaphosphate (4/4.) were less effective against Staph. aureus than against Sc.faecium. Results were more satisfactory when the substances to be tested were used in combinations. Combination of Sodium pyrophosphate with either Lauryl gallate (4/5.) or Lysozyme (4/6.) or Sodium lauryl sulfate (4/7.) gave good effects. Combination of Sodium metaphosphate with Lauryl sulfate (4/8.), and combination of Sodium lauryl sulfate with Lauryl gallate (4/11.) or Propyl gallate (4/12.) also produced appreciable effect.

1.23 Reduction of thermal resistance of spores of B.subtilis

Various substances which were effective against Sc.faecium, also were tested on cultures containing spores of B.subtilis, and in a few experiments on spores of B.stearothermophilus. Positive results were obtained with Sodium lauryl sulfate (5/1.) and oligophosphates (Sodium pyrophosphate (5/3.), Fibrisol (5/2.)). However, the reduction of D-values was lower than in the preliminary trials with Sc.faecium (Sodium lauryl sulfate o,o5 %, DVR 24 %, o,oo5 %, DVR 8 %; Sodium pyrophosphate o,5 %, DVR 29 %; Fibrisol o,5 %, DVR 2o %).High effects were obtained with Dequaliniumchloride (5/4.) and 1-Hexadecyl-pyridinium-bromide (5/5.) (DVR 8o % and 46 % resp.). Use of Sodium lauryl sulfate in combinatio with either curing salt (5/6.), or Fibrisol (5/7.)

or Sodium pyrophosphate (5/8.) resulted in summation of efficiency (DVR 17 %, 44 % and 41 %, resp.). Heat resistance of spores of B.subtilis was not affected by 5-Diazo-uracil, Lauryl gallate, and Propyl gallate; the effect of Lysozyme was uncertain. After heating, all cultures were incubated for several days; viable test organisms (B.subtilis and B.stearothermophilus) showed no sign of growth in cultures containing effective substances, while extensive growth developed in control cultures where no substances had been added. Similary, Lysozyme inhibited germination of spores, but did not kill them. Since no microbial growth developed in non-heated cultures containing Dequaliniumchloride, 1-Hexadecyl-pyridinium-bromide, Sodium lauryl sulfate or phosphates or one of the above mentioned combinations, those substances should be classified as inhibitors.

Spores of B.subtilis were also used to test the efficiency of various amino acids and amino acid derivatives part of which had been found capable of reducing thermal resistance of other test organisms (table 6). The following substances proved highly effective: N-Acetyl-3,5-diiodo-L-tyrosine (DVR 72 %), DL- -Acetamidoindol-3-propionic acid (DVR 63 %), DL-2-Acetamido-4-mercaptobutyric acid γ— (thiolactone) (DVR 61 %), 3-Acetoxy-DL-alanine (DVR 51 %), and Glycyl-glycin-ethylester-hydrochloride (DVR 4o %) (6/1.-5.). Glycyl-DL-leucine (DVR 25 %), and DL-2-Acetamido-3-methylbutyric acid (DVR 25 %) were less effective (6/6. and 7.). The efficiency of most of these substances is due to the fact that they are able to reduce the pH of the medium. Only Glycyl-DL-leucine showed specific effect, i.e. it was practically not dependent upon changes of pH. In a separate series of experiments controlled pH adjustments were made to detect eventual specific activity. It was found that even without use of

amino acids or amino acid derivatives D-value was decreased by about 75 % as a result of addition of lactic acid which reduced pH from 7,1 to 6,o.

In the tests with B.subtilis no significant reduction of D-values was attained by EDTA. However, subsequent storage of cultures resulted not only in an inhibition, but also in a remarkable reduction of numbers of spores. Drop in viable counts was more marked than in non-heated control cultures containing EDTA at o,o5 %. A similar effect was obtained with Sodium ethylene diamine-tetraacetate (o,o5 %).

Methanol extract of erythrocytes also produced reduction of thermal resistance of B.subtilis.

2. Experiments with vegetative germs and spores in emulsions

2.1 Materials and methods

The test organisms used were Sc.faecium, Staph. aureus SG 511 and spores of B.subtilis. Experiments were conducted in liquid and solid emulsions.

Composition of emulsions:

Liquid emulsions: glucose broth 8,5 parts
sunflower seed oil 1,o parts
sodium caseinate o,5 parts

Solid emulsions: water 5 parts
lard 5 parts
soybean protein 1 parts.

Liquid emulsions were prepared cold and then subjected to short-time heating at 118°C. For the preparation of solid emulsions, first the lard was melted and then allowed to cool about 4o°C. After cooling test organisms and substances to be tested were added and mixed with the lard, using a mixer. Finally the protein emulsifier was worked into the material; during the process of homogenization the required amount of hot water having a temperature of 7o°C was added; with this, the temperature of the

emulsion was brought to about 5o°C. Liquid emulsions were filled in test tubes, solid emulsions in small cans of sheet steel (5o g), and then heated in a water bath. Processing was continued as described under 1.1. The substances tested were Sodium pyrophosphate, Fibrisol, Lauryl gallate, Propyl gallate, Lysozyme, and Sodium lauryl sulfate. The substances were added alone or in combinations.

2.2 Results

2.21 Sc.faecium in liquid emulsions

Results are summarized in table 7. o,1 % Lysozyme (7/1.) produced a marked effect and gave a DVR of 39 % (55°C) and 3o % (6o°C). o,o5 % Propyl gallate (7/3.) also significantly reduced thermal resistance of Sc.faecium. Lauryl gallate produced a similar effect, depending upon concentration. Of the combinations used, particularly those composed of Lysozyme plus Lauryl gallate (7/4.), Lysozyme plus Sodium lauryl sulfate (7/5.) and Lysozyme plus Sodium pyrophosphate (7/6.), and Lauryl gallate plus Sodium lauryl sulfate (7/7.) gave satisfactory results, while Lauryl gallate in combination with Sodium pyrophosphate (7/8.) was far less effective.

2.22 Sc.faecium in solid emulsions

Data reported in table 8 indicate that Propyl gallate (8/1.) and Sodium lauryl sulfate (8/4.) gave satisfactory results, while the effect of Lysozyme (8/3.) was less marked, but still significant. As in liquid emulsions, range of efficiency significantly rose in solid emulsions, when substances which had given good effect alone, were used in combination. Percentage of DVR was 8o % and more in this case. Even very low concentrations resulted in marked reduction of D-values. It should be noted that Lauryl gallate and Propyl gallate produced bluish discoloration of emulsions.

2.23 Staph. aureus SG 511 in liquid emulsions

As is shown in table 9, Lysozyme (9/1.), Lauryl gallate (9/2.), Sodium lauryl sulfate (9/3.), and Sodium pyrophosphate (9/4.) reduced thermal resistance of the test organism; However, final effects were dependent upon the concentrations used. The combination of Sodium pyrophosphate and Lauryl gallate failed to increase efficiency (9/5.).

2.24 Spores of B. subtilis in solid emulsions

Fibrisol and Sodium Lauryl sulfate were used alone or in combination with each other or with curing salt. Effects upon B. subtilis were satisfactory (DVR 60 - 70 %), the other part rather unsatisfactory (DVR 20 %). During subsequent incubation mutlipli-cation of germs occurred, however, bulging was not seen in the cans containing material treated with the above mentioned substances, while all control samples which had not been treated with these sub-stances were liable to bulging. No explanation was found for the great differences with regard to the effects on thermal resistance of spores, and the non-occurrence of bulging in the treated samples which presented the same viable counts as untreated controls.

3. Experiments with meat-fat-water mixture

3.1 Materials and methods

The test organisms were Sc.faecium, and B.subtilis which was used in a separate test series. Composition of meat-fat-water mixture was as fallows: 6o parts beef, 2o parts lard, 2o parts water; curing salt was added at 2 %. Test organisms and substances to be tested were added while the mixture was prepared. Control sample were prepared without addition of substances. The mixture was tubed in pyrex vials fitted with a closing device (Ø 18 mm, 6o mm long)or, in part of experiments, filled in 5o g cans, and then

heated in a water bath. After heat processing, samples were cooled rapidly and then bacteriological examination was made. Initial counts were assessed immediately prior to heating.

3.2 Results

Results are summarized in table 1o. Concentrations of o,o2 or o,o5 % Lauryl gallate (1o/14.) and Propyl gallate (1o/19.), resp., produced slight effect only. As was stated earlier, the addition of gallates also gave rise to bluish discoloration of fat. Sodium lauryl sulfate (1o/2o.) gave positive results in part of experiments, even at low concentrations, yet did not prove fully reliable. Under the conditions of the experiment, Dimethyl-glyoxal (1o/8.) resulted in marked reduction of D-values. A highly disagreeable odor appeared as substantial disadvantage.

Dimethyl-α,α'-dichlorsuccinate (1o/7.) resulted in a DVR of 83 % which indicated a high level of efficiency. Samples containing the substance presented a slighly abnormal aromatic odor and pH was lower than in controls, the difference being up to o,3.

Acetamidoacetic acid (1o/1.), L-Acetamidosuccinic acid (1o/2.), N-Acetyl-L-glutamic acid (1o/3.), Citraconic acid (1o/4.), D-Glutamic acid (1o/9.) and Lactic acid (1o/13.) partly produced significant effect. These substances also reduced pH which, depending upon the increase in acidity, was associated with a more or less marked decrease of water binding capacity of the meat-fat-water mixture. The slightly soluble vitamin K_3 (1o/16.) showed only moderate efficiency, in higher concentrations it caused yellowish discoloration of the meat-fat-water mixture. Vitamin K_5 (1o/12.) produced no, or only slight, reduction of D-values. A concentration of o,o1 % resulted in bluish discoloration of fat.

Sodium pyrophosphate (1o/21.) gave a DVR of 27 % at 68°C. No immediate effect was obtained with GdL (o,1 % and o,2 %) at 6o°, 65° and 68°C. However, a decrease in the numbers of spores was observed during subsequent storage.

4-Hexylresorcinol (o,o5 %) yielded a DVR of 4o % at 6o°C; at 68°C percentage of DVR averaged only 17 % (1o/11.).

Concentrations of o,o5 and o,o8 % Sorbic acid produced a 2o % reduction of D-values (1o/22.). Level of pH was not influenced by o,o5 %, while after addition of o,o8 % pH was lower by o,15 than in controls.

Concentraions of o,o5 % and o,o1 % Nordihydro-guaiaretic acid had a comparatively good effect and yielded a DVR of about 25 % (1o/17.). At these concentrations the substance practically did not affect pH.

The range of efficiency of Lysozyme (1o/15.) was varying according to the pretreatment of the material under test. Heating to 6o°C immediately after addition of Lysozyme in concentrations of o,1 % and o,o5 % resulted in an average DVR of 35 % and 15 %, resp., while the percentages of DVR reached 79 % and 68 % when the samples were first stored at 5°C for 16 hours and then at 3o°C for 2 hours before they were heat-processed at 6o°C. Similarly, increased efficiency was observed when heat processing was preceded by cold storage only. In case of immediate heat treatment at 6o°C a concentration of o,o5 % Lysozyme resulted in a 15 % DVR, where as the percentage of reduction was 38 % when heating was preceded by a 16-hour storage at low temperature. Heating to 68°C proved less effective. Effects were insignificant and not safe when concentration of

A concentration of o,o1 % Dequaliniumchloride (1o/5.) showed satisfactory efficiency at 6o°C; percentage of DVR was about 5o %. However, the substance was only slightly effective at 65°C and 68°C.

1-Hexadecyl-pyridiniumbromide (1o/1o.) was highly effective in all tests made on meat-fat-water mixture. With a concentration of o,o1 % DVR was 55 % at 6o°C, 99 % at 65°C, and 95 % at 68°C. Even a concentration as low as o,oo5 % showed marked efficiency.

Of all substances tested 5-Diazo-uracil (1o/6.) was most effective. A concentration of 1o ppm resulted in marked reduction of D-values, the percentages averaging 86 % and 6o %, resp., at 6o° and 65°C. Addition of 5 ppm also produced significant effects (DVR 5o % and 63 %).

In meat-fat-water mixture inoculated with Sc.faecium EDTA and GdL failed to lower D-values; in samples containing B.subtilis slight reduction of D-values was obtained with these substances. Similarly to what had been seen in glucose broth cultures of B.subtilis and B.stearothermophilus containing Sodium lauryl sulfate and Sodium pyrophosphate (Fibrisol), a reduction of the number of spores was noted at subsequent storage. It was found that the effect of EDTA on spores of B.subtilis is dependent upon the length of previous heat exposure, in that killing rate is growing with the lenght of previous heat treatment.

The other substances which had been found effective in glucose broth, were ineffective in meat-fat-water mixture. Several substances could not be used for further investigations owing to untoward effects upon odor, flavor or color of the medium.

4. Discussion

The purpose of the investigations was to find substances which are able to produce significant reduction of thermal resistance of micoorganisms. Non-sporulating test organisms used were Sc.faecium and Staph. aureus SG 511; Sc.faecium was selected on the basis of its high heat resistance and owing to the importang role this germ plays in the production of pasteurized meat products such as hams etc.; Staph. aureus was chosen owing to its hygienic significance. In addition, tests were made which involved B.subtilis, a relatively common sporulating contaminant of meat, and B.stearothermophilus, a very heat resistant species. Choice of temperatures was so as to ensure sufficient prolongation of thermal death period of test organisms, which allowed for eventual differences to be shown more clearly. Moreover, ranges of temperature were nearly the same as are used in pasteurization of meat products. The choice of which substance to use was governed by the objective of the work, yet there was only scarce information available in pertinent literature.

The substances tested can be classified in groups and essentially include acids, particularly amino acids and their derivatives, salts, enzymes, several vitamins and other compounds. In selecting the substances care was taken, in general, to avoid the use of inhibitors (see page 8). This is the reason why, e.g., antibiotics were not used in the investigations. However, it appears difficult to make a clear separation between inhibitors and non inhibitors, since the inhibitory action of a substance may be dependent upon its concentration or, on the other hand, on other environmental factors.

Hence, in the course of the investigation, some of the substances tested proved to act as inhibitors. Moreover, it was intended to use a few inhibitors in the experiments to determine whether they also are able to reduce thermal resistance of microorganisms; in the second place, they were intended to provide a useful basis of comparison for other substances which did not act as inhibitors, but produced specific and significant reduction of heat resistance of microorganisms.

Of the substances which reduced thermal resistance of test organisms in glucose broth, it is the group of acids, and in particular amino acids and their derivatives, that deserves to be mentioned first. However, it should not be disregarded that mere reduction of pH significantly lowers thermal resistance of microorganisms; this may be considered as non specific effect. The effect of the acids under examination upon pH was widely varying. So one could except that there was a close relationship between levels of pH of the medium and DVR rates; yet this was not the case. The correlation coefficient was $r = -0{,}20$ and did not significantly differ from zero, which suggested that the effects produced by the tested acids were for the most part substance-specific. For instance, Nordihydroguaiaretic acid (0,01 %) failed to lower pH of the medium, but reduced D-values by 95 % at 60°C. The substance did not show the characteristic properties of an inhibitor. 2-Acetamido-4-(methylthio)-butyric acid lowered pH to 5,0, but reduced D-values by 38 % only.

Of the salts and saline substances examined Sodium lauryl sulfate, Lauryl gallate and Propyl gallate, Sodium metaphosphate and Sodium pyrophosphate gave results that were promising for future research,

while among ferments and ferment preparations it was only Lysozyme that showed a high level of efficiency. In relation to concentration, the most significant effect was obtained with 5-Diazo-uracil. As opposed to other very effective substances, this chemical agent showed no inhibitory effect in non-heated samples. When making allowance for the concentrations used, combination of certain substances partly resulted in increase of efficiency. Only in one case, i.e. when Sodium lauryl sulfate was used in combination with Potassium iodide, efficiency was lower than when both substances were used alone.
A number of substances which were effective against Sc.faecium were also tested on Staph. aureus SG 511. Particulary Lysozyme and Sodium lauryl sulfate were less powerful in this case than against Sc.faecium. In general, combination of substances also gave lower thermal resistance reduction rates with regard to Staph. aureus. However, this ist not due to the fact that thermal resistance of Staph. aureus is less susceptible to external influences, but rather to the high natural thermal sensitivity of this microbial species, which in turn necessarily results in lower rates.

Part of substances under test were less effective against B.subtilis than against Sc.faecium. This is especially true for Sodium lauryl sulfate alone or in combination with curing salt, Oligophosphate, and in particular for 5-Diazo-uracil, Lauryl gallate and Propyl gallate which were ineffective against spores.

The effects of Sodium lauryl sulfate and Sodium pyrophosphate which gave DVR rates of 24 % and 29 % still can be considered as satisfactory. Dequaliniumchloride and 1-Hexadecyl-pyridiniumbromide showed no drop in efficiency. Combinations containing Sodium lauryl sulfate also gave marked effects; percentage of DVR was 4o %. The observation that during incubation of heat-processed samples spores of B.subtilis and B.stearothermophilus which survived heating failed to germinate in presence of effective substances, and even were killed later with the progress of storage, appears to be of practical importance. EDTA and the Sodium salts of this acid, and Lysozyme failed to influence thermal resistance of the spores of B.subtilis, or their effects were not safe, however, these substances inhibited germination of spores, and in case of EDTA and the Sodium salts of this acid vayring numbers of spores were killed during subsequent storage. Against B.subtilis several amino acids and amino acid derivatives were highly powerful, yet the effect was mainly due to changes of pH. Reduction of pH of the medium from 7.1 to 6.o gave a DVR of about 77 %. Only Glycyl-DL-leucine showed specific action against spores of B.subtilis.

In this respect, it is also noting that only part of these substances which were effective against Sc.faecium could be tested against spores in the course of the present research project.

Only small number of the substances were tested in emulsions; in general, a lower range of efficiency was obtained. This is especially true for the experiments with Sc. faecium in liquid emulsions. A marked increase in efficiency was obtained with combinations of substances. It is noteworthy that

the effects of tested substances upon Sc.faecium were consistently more pronounced in solid emulsions than in liquid emulsions. Propyl gallate (o,o5 %) gave a DVR of 5o %; Lysozyme (o,o5 %) resulted in a DVR of 3o %, and Sodium lauryl sulfate (o,o1 % and o,oo3 %) yielded a DVR of 6o % and 35 %, resp. These values are not significantly lower than those attained in glucose broth. Sodium lauryl sulfate in combination with Sodium metaphosphate, Lysozyme, and Propyl gallate showed not only marked rise in efficiency in solid emulsions, but reached a very high level of efficiency as compared with the results obtained in glucose broth. In a number of experiments involving Sodium lauryl sulfate alone or in combination with other substances, it was observed that in solid emulsions which during preparation were exposed to 5o - 53°C for a few minutes, initial viable counts invariably were lower than counts assessed in control samples processed under identical conditions. Differences in viable counts were up to two log cycles. Only when concentrations of Sodium lauryl sulfate dropped below o,oo2 % initial counts were similar to those observed in controls.

These findings are highly important in that in many meat products fat is present in form of solid emulsion, and thus they allow to draw conclusions as to which effects the tested substances may have in meat products.

It was in particular Lysozyme and Sodium lauryl sulfate that were effective against Staph. aureus SG 511 in liquid emulsions, giving higher DVR rates than were obtained in glucose broth. The explanation for this is that D-values generally were higher in emulsion than in glucose broth. Fat-soluble Lauryl-gallate was less effective than it was in glucose

broth. This may be due to the fact that owing to its high fat-solubility there was a shift of the dissolved substance to the fatty phase, and in consequence of this concentration of the agent was lower in the liquid phase.

In the final stage of the investigations substances which had proved to be effective in glucose broth, were tested in a meat-fat-water mixture which was similar in composition to Frankfurter-style sausage and luncheon meat.

5-Diazo-uracil was most effective in these tests. A concentration of 1o ppm still resulted in a DVR of 86 % at 6o°C, and in a 65 % DVR at 65°C. Even, a concentration of 5 ppm still gave DVR rates of 5o % and 63 %. From this it appears that this substance would be well suited for practical use in meat products to destroy vegetative microbial cells, provided there are no toxicological hazards involved. Dimethylglyoxal also gave satisfactory results, but is not suited for technological use owing to its disagreeable odor. 1-Hexadecylpyridiniumbromide, a quaternary ammonium compound, also was very powerful, however the substance has an inhibitory effect (disinfectant) and its use as an additive to meat products would be highly problematic.

A number of acid substances also were highly effective yet it was in first line the reaction to the drop of pH that were most marked. Levels of pH below 5,5 are not favorable since the process of binding in minced meat-fat-water mixture is impaired in this case and, in particular, a certain amount of water is lost; as a result of this, the final product is not of acceptable quality. Gallates and vitamin K_3 and vitamin K_5 presented only moderate to-slight degree of efficiency and in addition, these substances

are not suited for practical use owing to discoloration of the meat-fat-water mixture.

Particular attention should be given to Lysozyme which according to the definition given on page 8 must be regarded as an inhibitor, but is fully inactivated at the temperatures used for heat-processing of meat products. Concentrations of o,1 % and o,o5 % Lysozyme resulted in DVR rates of 35 % and 15 %, when the mixture was heated immediately after preparation. Significantly higher percentage of DVR was generally obtained, when the mixture was stored some hours prior to heating. This observation may be of practical importance for meat industry in that a number of meat products, e.g. Frankfurter-style sausages, are exposed to slightly increased temperatures at smoking prior to high-temperature processing, and as a result of this there would be an optimal range of temperature ensuring full efficiency of Lysozyme for a given length of time.

Nordihydroguaiaretic acid and Sodium pyrophosphate also are substances which can be effectively used in the manufacture of meat products. Oligophosphates present a peculiar technological advantage in that they are able to improve the binding qualitiy of meat, and consequently, in many countries, their use as technological adjuvant for meat products, such as Frankfurter-style sausages, luncheon meat, and even hams, is admitted by law. The good efficiency against microorganisms was confirmed by our experiments. Rate of reduction of D-values is not very high, i.e. 27 % only, but at subsequent storage a further reduction of viable germs (Sc.faecium, B.subtilis, B.stearothermophilus) is obtained; this fact ensures

safe keeping quality of all products treated with oligophosphates. In this respect, Glucono-delta-lactone (GdL) also appears to be of some interest; this substance only slightly reduced D-values of Sc.faecium, B.subtilis and B.stearothermophilus, but led to a marked decrease in numbers of germs at subsequent storage. GdL also is recommended as an adjuvant for heat-processed meat products, because it enhances the reduction of nitrite, and in consequence of this, the formation of nitroso-myoglobin. In this connection one also should refer to EDTA which practically failed to reduce D-values of Sc.faecium and B.subtilis, but also led to a further reduction of numbers of germs at subsequent storage. A peculiarity of EDTA is that the rate of reduction of viable counts is dependent upon the length of previous heat-exposure, whereas this relationship was not observed with Sodium pyro-phosphate and GdL.

5. Conclusions

Again, the investigations have shown that heat resistance of microorganisms can be reduced by certain additives. Efficiency largely depends upon environmental conditions. E.g., a large number of substances which were effective against Sc.faecium in aqueous medium (glucose broth) showed no or only slight effect in meat-fat-water mixture, while others were fairly effective. Substances that were highly powerful against vegetative germs, were not or less effective against spores, while part of these additives, when used in combination, resulted in marked rise of Efficiency. It should also be noted that certain substances first produced only slight or no reduction of D-values, but later during storage they inhibited growth of test organisms or even reduced viable counts.

substances are suited as additives to heat-processed meat products to reduce thermal resistance of micro-organisms. This particularly applies to meat products which are subject to pasteurization only. Use of these substances may also be of advantage with regard to the stabilization of canned food. Potential toxicological risks associated with the use of several substances still need to be examined.

6. Need for additional Research

All substances that were effective against the test organisms used, should also be assayed in further on other organisms, especially clostridial spores. Moreover, these substances should be used under practical conditions in the manufacture of canned meat and pasteurized meat products. Investigations are required to determine whether effective substances are suitable for substitution of nitrite which, as is well known, is able to join secondary amines and form cancerogenic nitrosoamines.

III. Studies on the effect of type of emulsifier on rate of heat transfer in emulsions and meat-bacon-emulsion mixtures

1. Material and methods

1.1 Preparation of emulsions and mixture

Following substances were used for the preparation of emulsions Glyceride emulsifier ("Invitor 96o", Dynamit Nobel AG., Witten Ruhr, FGR),
Sodium caseinate ("FN5" Tari, Braunau, Austria),
Soybean protein ("Promine DLW", Central Soya, Chicago, Illinois, USA),
Lecithin (Eier-Lecithin, Merck, Darmstadt FGR),
Oligophosphates (Gebr. Giulini, Ludwigshafen, FGR).

Fats: Lard, coco-nut oil, sunflower-seed oil, and beef suet.

In preparing emulsions with protein emulsifiers, melted fat was mixed up with protein emulsifier at 5o^{o}C, with or without addition of lecithin or

phosphates, and the mixture homogenized. Then water heated to about 100°C was added and homogenization continued until a viscid mass had formed. In preparing emulsions with glyceride emulsifier, fat and emulsifier were mixed and heated together to 60 - 70°C, then water of same temperature was added and the mixture allowed to emulsify.

Alltogether 22 differently formulated emulsions were used (see table 11). For the preparation of meat-bacon-emulsion mixture, first meat and bacon were run through a mincer (size of slots 13/10 mm) and then varying proportions of meat and bacon were mixed with emulsions to obtain the mixtures listed in table 12. Comparative measurements were made at the same time on minced bacon without other material being added.

1.2 Measuring technique

Emulsions and mixture were filled in 1 kg tin cans and the cans closed with a lid on which a heat detector was mounted exactly in the center. The canned good was placed in a thermostatically regulated waterbath. Initial temperature of both waterbath and contents of cans was 20°C. A second sensing element was put in the waterbath. Heating curves were recorded by a micrograph supplied by Kipp and Zonen. Recording began when temperature of water-bath reached the scheduled final temperature (65 and 69°C, resp.).

1.3 Determination of melting range of lard with and without emulsifier added

5 g melted lard or a mixture of lard and emulsifier were filled in a test tube and a thermometer was introduced into the tube so that the bulb immerged centrally in the liquid fat. Then the contents of the tube were allowed to solidify. After solidi-

in diameter) were placed on the surface of the fat. The tube was placed in a conical flask filled with water so that the water level was higher by 1 cm than the level of fat in the tube. Then the flask was slowly heated (about 3o" per every 1°C increase in the fat). The temperature reached at the moment when the marbles began to immerge in the fat was taken as initial melting temperature, the end temperature was recorded when the lard was completely melted. In mixtures containing milk protein, the latter sedimented for the most part, but nevertheless the complete melting process could be observed clearly. Mixtures of lard and emulsifiers were prepared as follows:
Mixture A: 1 part sodium caseinate and 5 parts lard. Half of the lard was melted at 5o°C and thoroughly mixed with the sodium caseinate; then was added the other half of the lard which previously had been heated to 1oo°C.
Mixture B: 1 part glyceride emulsifier and 5 parts lard. Both components were mixed at 7o°C.

1.4 Calculation of an empirical heat penetration coefficient

To come to a better understanding of, and have a safe basis of comparison for, results of measurements an empirical heat penetration coefficient $C = \frac{A}{B} \times 1o$ has been introduced. The coefficient is obtained by multiplying by 1o the quotient resulting from the division of the temperature difference recorded between minute 15 - 3o after beginning of measurements (A) by the difference in temperature between waterbath and emulsion (mixture) (B). The reason why the 15 - 3o minute period was selected for the purpose is that the measuring device tended to work regularly after 15', and the emulsion showed no heat-induced changes of the fine structure

at this time (macroscopically no change was observed until the end of temperature recording).

2. Results

Measurements on emulsions which were composed of 1 part emulsifier and 5 parts lard and 5 parts water indicated that protein emulsifiers (sodium caseinate, soybean protein) gave a higher rate of heat penetration than did glyceride emulsifier (table 11 and fig.1). Difference was greatest with lard (fig.2, table 11/1.-3.), and lowest with beef suet (fig.2, table 11/7.-9.). Sunflower-seed oil and coco-nut oil occupy an intermediate position with respect to differences in rate of heat transfer resulting from the use of either protein emulsifiers or glyceride emulsifier (fig.2, table 11/4.-6. and 1o.-12.). Soybean protein gave more viscid emulsions than were obtained with milk protein.

Use of lecithin or phosphates in lieu of part of protein or glyceride emulsifier resulted in rather slight acceleration of heat transfer when lecithin was substituted for glyceride emulsifier (11/3.14.16.). No appreciable effect was seen with milk protein (11/1.13.15.). Higher water content of emulsion resulted in more satisfactory heat penetration (see table 11/2. and 17.; 5. and 18.; 11. and 2o.; 8. and 19.).

The emulsion containing milk protein where fat: water ratio was 1:2 (11/21.) was far less viscid than that prepared with glyceride emulsifier (11/22.), and not so viscous as the other emulsions (11/1.-2o.). At microscopical examination of the glyceride emulsion which was more viscid in consistency it was found

that individual particles seized 2 - 3 µm were lying close together, while in emulsions prepared with milk protein the particles were varying in size, namely from 1.3 - 5 µm, and there was more space between them. Milk protein emulsions which contained a greater amount of water and were practically liquid in consistency allowed for convection currents to appear, and as a result of this increase of temperature, while measurements were taken, was faster than it was in glyceride emulsions (11/21. 22.).

The determination of melting range with and without emulsifier added showed the following results:

Lard + Sodium caseinate 26 to 48°C,
Lard + Glyceride 35 to 61°C,
Lard 26 to 48°C,
Glyceride 51 to 63°C.

Measurements of rate of heat transfer in minced hog fat (bacon without meat or emulsifier added) also revealed that convection currents occurred as soon as fat began to melt (fig.1 and table 12/9.).

In mixtures containing meat, rate of heat transfer was dependent on the quantity of meat added in that there was an acceleration of heat penetration when the proportion of meat was increased. Heating was significantly quicker in mixtures composed of bacon and emulsions (12/1. and 2.) than in minced bacon without emulsion added (12/9.). Rate of heat transfer was slightly better in mixtures containing protein emulsions in lieu of glyceride emulsions. Acceleration was more significant when both meat and bacon were added to the mixture.

3. Discussion

Rate of heat transfer in heat processed food essentially contributes to the efficiency of thermal destruction of microorganisms. The slower heat penetration, the longer are times of exposure needed to attain the desired effect. In this case it is not possible to avoid thermal injuries to the canned good and this is necessarily associated with deterioration of quality and loss of nutritive value. This particularly applies to canned meat of solid consistency such as luncheon meat etc, where the outer parts are more or less over-heated, depending upon rate of heat penetration. Accelaration of heat transfer ensures safe destruction of micro-organisms and in addition reduces the extent of injury to the quality of the product.

Heat transfer may be effected by conduction, radiation or convection. As differences in temperature are relatively low, radiation can be disregarded as a means of heat transfer in canned food. In canned meat products where part of components are liquid or tend to melt or release juice at heating, convection currents appear to be largely responsible for heat transfer. The amount of convection heating can still be increased by shaking the cans during the process of sterilization. Yet, the problem is more complex in that meat products, in addition to occasionally liquid components, always contain solid parts which - much the same as meat products which exclusively contain material of solid or paste-like consistency - only allow for heating by conduction. The purpose of this investigation was to determine whether and how it may be possible to enhance rate of heat conduction in canned food by varying the proportions of components added. For this purpose, rate of heat transfer was studied in mixtures which completely or partially were composed of viscid emulsions. Particular

attention was given to the effect which the type of emulsifier may have on heat transfer in emulsions. No useful relevant information was found in literature.

The finding that the type of emulsifier has a marked influence on the rate of heat transfer in emulsions is the most prominent result of our investigation. In emulsions prepared with protein emulsifiers (sodium caseinate, soybean protein) heat transfer was far more satisfactory than it was in emulsions prepared with glyceride emulsifier. This may be explained on the basis of differences in structure, and in this respect it may be essential that emulsions prepared with protein emulsifiers are in principle fat-in-water emulsions, while the reversal can be said for emulsions containing glyceride emulsifier (water-in-fat emulsion). It may be postulated in this connection that the main component used forms a continuum and, as a result of this, tends to determine rate of heat transfer.

The fact that emulsions containing soybean protein were more viscid than those prepared with sodium caseinate may be due to the better water binding quality of soybean protein whereby fat droplets are not allowed to slide freely by each other. This effect had no influence upon rate of heat transfer.

As was expected variations in the effects of type of emulsifier on heat transfer were significantly marked in meat-fat-emulsion mixtures. Differences were very slight, i.e. statistically insignificant (see table 12, C-values).

It is also worth noting that the type of fat used changed to some extent the specific effect which certain types of emulsifier exerted upon rate of heat transfer (fig.2). In emulsions which contained glycerides, rate of heat transfer was slowest when lard was used, and highest with beef suet. The reverse conditions were found in emulsions prepared with soybean protein. Fat (lard, beef suet) showed no, or only slight, influence on emulsions prepared with sodium caseinate.

4. Conclusions

Results mey prove of advantage in the manufacture of meat products of paste-like consistency, since the above named emulsifiers are also recommended for the stabilization of these products. Another practical proposition is to substitute, to a large extent, emulsions for fat in meat products suited for the purpose.

5. Further investigations

Future investigations should be centred upon the study of potential influences which the structure of emulsions may have on heat conductivity. Moreover, additional technological studies are required to examine possibilities of practical application of the results in meat technology.

Tab.1: Substances which were tested in glucose broth cultures to study their efficiency as reducents of thermal resistance of microorganisms

1. Acetamidoacetic acid
2. L-2-Acetamidoglutaramic acid
3. DL-α-Acetamidoindol-3-propionic acid
4. DL-2-Acetamido-4-mercaptobutyric acid γ-(thiolactone)
5. 2-Acetamido-3-mercaptopropionic acid
6. DL-2-Acetamido-3-methylbutyric acid
7. 2-Acetamido-4-(methylthio)-butyric acid
8. L-Acetamidosuccinic acid
9. N^{α}-Acetamido-L-tyrosineamide
10. Acetic acid
11. Acetoin (Acethylmethylcarbinol)
12. 3-Acetoxy-DL-alanine
13. N-Acetyl-3,5-diiodo-L-tyrosine
14. N-Acetyl-L-glutamic acid
15. DL-Alanyl-glycine
16. DL-Alanyl-DL-phenylalanine
17. Alcalase (Novo Industrie A/S Copenhagen, Denmark)
18. Alginic acid
19. Aminoacetic acid
20. Aminobutyric acid, GABA
21. D-Aminocaproic acid
22. 2-Amino-2-deoxy-D-glucose-hydrochloride
23. 1-Amino-dodecan (Laurylamin)
24. 2-Amino-ethane-1-sulfonic acid (Taurin)
25. D-2-Aminoglutaramic acid
26. L-2-Aminoglutaramic acid
27. L-2-Amino-5-guanidinovaleric acid
28. D-α-Aminohydrocinnamic acid
29. D-2-Amino-3-hydroxybutyric acid
30. L-2-Amino-3-hydroxybutyric acid
31. D-2-Amino-3-hydroxypropionic acid
32. DL-2-Amino-3-hydroxypropionic acid
33. DL-α-Amino-4(or 5)-imidazolepropionic acid

34. L-α-Amino-4(or 5)-imidazolepropionic acid
35. L-2-Amino-3-mercaptopropionic acid
36. D-2-Amino-3-methylbutyric acid
37. DL-2-Amino-3-methylbutyric acid
38. L-2-Amino-3-methylbutyric acid
39. D-2-Amino-4-(methylthio)-butyric acid
4o. L-2-Amino-4-(methylthio)-butyric acid
41. DL-2-Amino-3-methylvaleric acid
42. L-2-Amino-3-methylvaleric acid
43. D-2-Amino-4-methylvaleric acid
44. DL-2-Amino-4-methylvaleric acid
45. L-2-Amino-3-phenylpropionic acid
46. D-2-Aminopropionic acid
47. L-2-Aminopropionic acid
48. 3-Aminopropionic acid
49. DL-2-Amino-5-guanidinovaleric acid
5o. D-2-Aminosuccinamic acid
51. L-2-Aminosuccinamic acid
52. DL-Aminosuccinic acid
53. L-Aminosuccinic acid
54. D-2-Aminovaleric acid
55. α-Amylase (Clarase)
56. Ascorbic acid
57. Ca-lactate
58. Citraconic acid
59. Citropepsin
6o. Cocarboxylase (Thiamine pyrophosphoric acid ester chloride)
61. Curing salt (99,5 % sodium chloride + o,5 % sodium nitrite)
62. Dehydroacetic acid
63. Dequaliniumchloride
64. L-2,6-Diaminohexanoic acid
65. Dimethylglyoxal (Biacetyl, Diacetyl)
66. Dimethyl-α,α'-dichlorsuccinate
67. 5-Diazo-uracil
68. Elaidic acid
69. Erythrocyte extract
7o. Ethylenediamine-L-tartrate

71. (Ethylenediamine-tetraacetic acid for metal titrations); Titriplex II (Merck, Darmstadt, Germany)

72. (Ethylenedinitrilo)-tetraacetic acid, EDTA (Schuchardt, München, Germany)

73. (Ethylenedinitrilo)-tetraacetic acid disodium salt

74. Ethyl valerate

75. Ficin

76. Fibrisol (Oligophosphate) Benkiser, Wiesbaden, Germany)

77. Fumaric acid

78. Glucono-delta-lactone (GdL)

79. D-Glutamic acid

8o. L-Glutamic acid

81. Glutamic acid monosodium salt

82. Glycolic acid (Hydroacetic acid)

83. Glycyl-DL-alanine

84. Glycyl-ethylaminoacetate

85. Glycyl-glycinethylester-hydrochloride

86. Glycyl-glycine

87. Glycyl-DL-leucine

88. Glycyl-DL-methionine

89. Hexadecyltrimethylammonium bromide

9o. 1-Hexadecyl-pyridiniumbromide

91. Hexocinase

92. Hexanoic acid

93. 4-Hexyl-resorcinol

94. N-Hippuroyl-glycine

95. N-Hippuroyl-DL-phenylalanine

96. Hyaluronidase

97. Hydrochloric acid

98. Hydroxocobalamin

99. Hydroxyammonium chloride

1oo. 1-Hydroxy-2-methyl-naphthalene-4-ammonium-chloride (Vitamin K_5)

101. 3-(p-Hydroxyphenyl)-D-alanine
102. 3-(p-Hydroxyphenyl)-DL-alanine
103. Hylak (metabolite of lactic acid-forming microbes)
104. 3-Indol-3-yl-D-alanine
105. 3-Indol-3-yl-L-alanine
106. meso-Inosit (Mesoinosit)
107. Inulin
108. Isobutyric acid (2-Methylpropionic acid)
109. Lactic acid
110. Lauryl gallate
111. Levulinic acid
112. DL-Leucyl-glycine
113. Lithium lactate
114. D-Lysine-monohydrochloride
115. Lysozyme
116. Magnesium citrate
117. DL-Malic acid (DL-Hydrosuccinic acid)
118. Maxatase (Royal Netherlands Fermentation Industries LDT., Delft, Netherlands)
119. Methyl-p-hydroxybenzoate
120. 2-Methyl-1,4-naphthoquinone (Menadion, Vitamin K_3)
121. Methylvanillate
122. Monoolein (Glycerinmonooleat)
123. Nalidixic acid
124. Nordihydroguaiaretic acid
125. Papain
126. Pectinase
127. Phthalic anhydride
128. Picolinic acid
129. Potassium iodide
130. Präparat 2200 A (Röhm and Haas, Darmstadt, Germany)
131. Propyl gallate
132. Pyridin-3-carboxamide (Nicotine amide)
133. DL-Pyroglutamic acid (DL-Glutamic acid γ-lactam)
134. DL-Pyrrolidine-2-carboxylic acid
135. L-Pyrrolidine-2-carboxylic acid

136. Rapidase (Société Rapidase, Seclin, France)
137. Ribonuclease
138. Sodium acetate
139. Sodium benzoate
14o. Sodium citrate
141. Sodium diacetate
142. Sodium laurylsulphate
143. Sodium "hexametaphosphate",(Graham's salt)
144. Sodium pyrophosphate
145. Sorbic acid
146. L-Tartaric, D-Tartaric acid
147. Trypsin

Tab.2: Substances active in reducing heat resistance of Sc. faecium in glucose broth (DVR = D-value reduction)

No.	Substance	Conc.%	pH+)	T°C	DVR %
1.	Acetamidoacetic acid	o,1	5,4	6o	65
		o,o5		68	22
2.	DL-α-acetamidoindol-3-propionic acid	o,1	5,5	6o	82
3.	DL-2-Acetamido-4-mercaptobutyric acid	o,1		6o	11
4.	2-Acetamido-3-mercaptopropionic acid	o,1	5,4	6o	91
5.	DL-2-Acetamido-3-methylbutyric acid	o,1		6o	41
6.	2-Acetamido-4-(methylthio)-butyric acid	o,1	5,o	6o	38
7.	L-Acetamidosuccinic acid	o,1	5,4	6o	91
8.	N-Acetyl-L-glutamic acid	o,1	5,4	6o	8o
		o,o5			7o
		o,o1		65	2o
		o,1		68	38
		o,o5			28
9.	D-2-Amino-3-hydroxy-propionic acid	o,1		6o	13
1o.	L-2-Amino-3-mercapto-propionic acid	o,1		6o	11
11.	DL-Aminosuccinic acid	o,1	5,4	6o	38
12.	L-Aminosuccinic acid	o,1	5,5	6o	9o
13.	Citraconic acid	o,1	5,4	6o	96
14.	Cocarboxylase	o,o8		55	21
		o,o5		6o	27
		o,o2			2o
15.	Dequaliniumchloride	o,o1		6o	99
		o,oo5			88
		o,o1		65	42
		o,o8		68	46

Tab.2 : continue

No.	Substance	Conc.%	pH+)	T°C	DVR %
16.	5-Diazo-uracil	o,o1		6o	99
		o,oo5			88
		o,oo2			94
		o,oo1			84
		o,oo1		65	67
		o,oo5		68	72
17.	Dimethylglyoxal	o,5 ml/1oo		6o	95
18.	Ethylenediamine-tetraacetic acid (Titriplex II) (EDTA)	o,1	5,4	6o	66
19.	Ethyl valerate	1 ml/1oo		6o	93
2o.	Fibrisol (Oligo-phosphate)	o,5		6o	12
21.	Glucono-delta-lactone (GdL)	o,1	5,8	6o	38
		o,2	5,5		81
22.	D-Glutamic acid	o,1	5,4	6o	9o
23.	1-Hexadecylpyridinium-bromide	o,o1		6o	8o
		o,o5		65	46
		o,oo3			16
		o,oo5		68	4o
24.	Hexanoic acid	5 ml/1oo	5,7	6o	96
25.	4-Hexylresorcinol	o,o1		6o	99
26.	N-Hippuroyl-glycine	o,1	6,4	6o	48
27.	N-Hippuroyl-DL-phenylalanine	o,1		6o	32
28.	3-(p-Hydroxyphenyl)-D-alanine	o,1		6o	29
29.	1-Hydroxy-2-methyl-naphthalene-4-ammonium-chloride (Vitamin K_5)	o,o1		6o	88
				65	4
3o.	Lactic acid	o,2 ml/1oo	5,4	65	8o
31.	Lauryl gallate	o,o2		5o	15
				55	71
				6o	42
		o,o1		55	41

Tab.2: continue

No.	Substance	Conc.%	pH+)	T°C	DVR %
32.	Lysozyme	o,1		55	73
				6o	42
		o,o5		55	66
				6o	36
				65	16
		o,o8		68	13
33.	2-Methyl-1,4-naphthoquinone (Vitamin K_3)	o,o1		6o	5o
34.	Methylvanillate	o,1		6o	62
35.	Nordihydroguaiaretic acid	o,o1		6o	95
				68	26
36.	Phtalic anhydride	o,1		6o	23
37.	Picolinic acid	o,o1		6o	12
38.	Potassium iodide	o,o5		6o	2o
39.	Propyl gallate	o,o5		55	8o
				6o	65
				65	33
4o.	DL-Pyroglutamic acid	o,1	5,4	6o	97
41.	Sodium diacetate	o,1	5,7	6o	55
		o,o5			21
42.	Sodium lauryl sulfate	o,o5		55	94
				6o	82
		o,o1		5o	6o
				55	98
				6o	88
		o,oo1		55	29
				6o	29
43.	Sodium metaphosphate ("hexametaphosphate")	o,5		55	61
		o,2			53
		o,5		6o	24
44.	Sodium pyrophosphate	o,5		55	51
		o,2			3o
45.	Sorbic acid	o,o8		68	21
		o,o5			19

Tab.3: Combinations of substances active in reducing heat resistance of Sc.faecium in glucose broth

No.	Substance	Conc.%	T°C	DVR %
1.	Sodium pyrophosphate + Lauryl gallate	o,2 + o,o1	5o	98
			55	51
			6o	58
2.	Sodium pyrophosphate + Lysozyme	o,2 + o,1	55	74
			6o	58
		o,2 + o,o5	55	62
			6o	42
		o,1 + o,o1	55	37
3.	Sodium pyrophosphate + Sodium lauryl sulfate	o,o5 + o,o5	5o	51
			55	75
			6o	86
4.	Sodium metaphosphate + Lauryl gallate	o,2 + o,o1	5o	28
			55	56
5.	Lysozyme + Lauryl gallate	o,1 + o,o1	5o	2o
			55	61
			6o	58
		o,o5 + o,o1	55	54
			6o	52
6.	Lysozyme + Sodium lauryl sulfate	o,o5 + o,o5	55	87
			6o	92
		o,o5 + o,oo5	55	51
			6o	37
		o,o1 + o,oo5	55	53
			6o	17
7.	Lysozyme + Cocarboxylase	o,o5 + o,o8	55	61
			6o	4o
8.	Sodium lauryl sulfate + Lauryl gallate	o,o5 + o,o5	5o	98
			55	97
			6o	99
		o,o1 + o,o1	5o	79
		o,oo2 + o,oo5	55	82
			6o	99
		o,oo1 + o,oo5	55	66
			6o	89
		o,ooo5 + o,oo5	6o	8o

Tab.3: continue

No.	Substance	Conc.%	T°C	DVR %
9.	Sodium lauryl sulfate + Propyl gallate	o,o5 + o,o5	55	93
			6o	87
		o,oo5 + o,o1	6o	96
		o,oo5 + o,oo5	6o	96
1o.	Sodium lauryl sulfate + Curing salt	o,oo5 + 2,o	6o	99
11.	Sodium lauryl sulfate + Potassium iodide	o,oo5 + o,5	6o	16
12.	Acetoin + Lauryl gallate	o,1 + o,o1	55	64
13.	Glucono-delta lactone + Curing salt	o,o5 + 3,o	6o	36
		o,o1 + 3,o	6o	O
14.	Glucono-delta-lactone + Ascorbic acid	o,1 + o,1	6o	89

Tab.4: Substances and combinations active in reducing heat resistance of Staph. aureus SG 511 in glucose broth

No.	Substance	Conc.%	T°C	DVR %
1.	Lysozyme	o,1	5o	14
		o,o5	5o	o
2.	Sodium lauryl sulfate	o,1	55	62
		o,o5	55	42
		o,o1	5o	28
			55	5o
		o,oo5	5o	15
			55	17
3.	Lauryl gallate	o,o2	5o	4o
4.	Sodium metaphosphate	o,5	5o	4o
5.	Sodium pyrophosphate + Lauryl gallate	o,2 + o,o1	5o	67
			55	17
6.	Sodium pyrophosphate + Lysozyme	o,2 + o,1	5o	5o
			55	5o
		o,2 + o,o5	5o	42
			55	5o
7.	Sodium pyrophosphate + Sodium lauryl sulfate	o,o5 + o,o5	5o	41
			55	95
8.	Sodium metaphosphate + Lauryl gallate	o,2 + o,o1	5o	67
9.	Lysozyme + Lauryl gallate	o,1 + o,o1	5o	45
		o,o8 + o,o1	5o	17
		o,o5 + o,o1	5o	35
		o,o1 + o,oo5	5o	36
			55	17
1o.	Lysozyme + Sodium lauryl sulfate	o,o5 + o,o5	5o	15
			55	3o
		o,o1 + o,o1	5o	23
			55	17

Tab.4: continue

No.	Substance	Conc.%	T°C	DVR %
11.	Sodium lauryl sulfate + Lauryl gallate	o,o5 + o,o5	5o 55	63 55
		o,oo1 + o,oo5	5o 55	62 75
12.	Sodium lauryl sulfate + Propyl gallate	o,o5 + o,o5	5o 55	36 53

Tab.5: Substances and combinations active in reducing heat resistance of spores of B.subtilis in glucose broth

No.	Substance	Conc.%	T°C	DVR %
1.	Sodium lauryl sulfate	o,o5 o,o3 o,o1 o,oo5	9o	24 24 17 8
2.	Fibrisol	o,5	9o	2o
3.	Sodium pyrophosphate	o,5	9o	29
4.	Dequaliniumchloride	o,oo5	8o	8o
5.	1-Hexadecyl-pyridinium-bromide	o,oo5	8o	46
6.	Sodium lauryl sulfate + Curing salt	o,oo5 + 2,o	9o	17
7.	Sodium lauryl sulfate + Fibrisol	o,oo5 + o,3	9o	44
8.	Sodium lauryl sulfate + Sodium pyrophosphate	o,oo5 + o,3	9o	41

Tab.6: Amino acids and amino acid derivatives (o,1 %) active in reducing heat resistance of spores of B.subtilis in glucose broth. (Temperatur 9o°C. pH prior to (a) and after (b) heat exposure)

No.	Substance	pH+) a	b	DVR %
1.	N-Acetyl-3,5-diiodo-L-tyrosine	6,7o	--	72
2.	DL-α-Acetamidoindol-3-propionic acid	6,45	--	63
3.	DL-2-Acetamido-4-maercaptobutyric acid γ-(thiolactone)	6,25	5,9o	61
4.	3-Acetoxy-DL-alanine	6,85	6,oo	51
5.	Glycyl-glycinethylester-hydrochloride	7,o2	6,35	4o
6.	Glycyl-DL-leucine	7,15	7,15	25
7.	DL-2-Acetamido-3-methyl-butyric acid	5,9o	--	25

+) Controls pH 7,15

Tab.7: Substances and combinations activ in reducing heat resistance of Sc.faecium in fluid emulsions (glucose broth:sunflowerseed oil:sodium caseinate= 8,5:1,o:o,5)

No.	Substance	Conc.%	T°C	DVR %
1.	Lysozyme	o,o5	55	26
			6o	16
		o,1	55	39
			6o	3o
2.	Lauryl gallate	o,o2	55	16
			6o	8
3.	Propyl gallate	o,o2	5o	23
			55	8
			6o	11
		o,o5	5o	44
			55	37
			6o	28
4.	Lysozyme + Lauryl gallate	o,1 + o,o2	55	48
		o,1 + o,o1	55	43
		o,o5 + o,o2	55	43
		o,o5 + o,o1	55	28
		o,1 + o,o2	6o	41
		o,1 + o,o1	6o	37
		o,o5 + o,o1	6o	27
5.	Lysozym + Sodium lauryl sulfate	o,o5 + o,o5	55	3o
			6o	24
6.	Lysozyme + Sodium pyrophosphate	o,1 + o,5	55	37
		o,1 + o,2	55	39
		o,o5 + o,5	55	13

Tab.7: continue

No.	Substance	Conc.%	T°C	DVR %
7.	Lauryl gallate + Sodium lauryl sulfate	o,o2 + o,o5	6o	42
		o,o1 + o,o5	6o	34
8.	Lauryl gallate + Sodium pyrophosphate	o,o2 + o,5	55	21
		o,o2 + o,2	55	8
		o,o1 + o,2	55	7

Tab.8: Substances and combinations activ in reducing heat resistance of Sc.faecium in solid emulsions (water:fat:soya-emulsifier = 5:5:1)

No.	Substance	Conc.%	T°C	DVR %
1.	Propyl gallate	o,o5	6o	5o
			65	5o
2.	Lauryl gallate	o,o1	6o	15
3.	Lysozyme	o,o5	6o	3o
4.	Sodium lauryl sulfate	o,o1	6o	6o
		o,oo3	6o	35
5.	Sodium lauryl sulfate + Propyl gallate	o,o5 + o,o5	6o	8o
		o,oo1 + o,o2	6o	54
		o,oo1 + o,o1	6o	4o
		o,o5 + o,o5	65	82
		o,o1 + o,o5	65	87
6.	Sodium lauryl sulfate + Lysozyme	o,o5 + o,o5	6o	79
			65	72
		o,o1 o,o2	6o	26
7.	Sodium lauryl sulfate + Lauryl gallate	o,oo3 + o,o5	6o	74
8.	Sodium lauryl sulfate + Sodium metaphosphate	o,oo3 + o,5	6o	76

Tab.9: Substances active in reducing heat resistance of Staph.aureus SG 511 in fluid emulsions (glucose broth:sunflower-seed oil:Sodium caseinate = 8,5:1,o:o,5)

No.	Substance	Conc.%	T°C	DVR %
1.	Lysozyme	o,o5	55	27
			6o	27
2.	Lauryl gallate	o,o5	6o	47
		o,o2	55	17
			6o	26
		o,o1	6o	25
3.	Sodium lauryl sulfate	o,o3	6o	98
		o,o1		86
		o,oo5		78
		o,oo3		47
		o,oo2		3o
		o,oo1		24
4.	Sodium pyrophosphate	o,5	55	14
5.	Sodium pyrophosphate + Lauryl gallate	o,2 + o,o2	55	2o
		o,2 + o,o1		2o

Tab.1o: Substances active in reducing heat resistance of Sc.faecium in meat-fat-water mixture

No.	Substance	Conc.%	T°C	pH+)	DVR %
1.	Acetamidoacetic acid	o,1	6o	5,35 (5,5o)	35
			6o	6,15 (6,3o)	12
			68	5,4o (5,62)	19
		o,o5	68	5,6o (5,7o)	23
2.	L-Acetamidosuccinic acid	o,1	6o	5,3o (5,55)	59
3.	N-Acetyl-L-glutamic acid	o,1	6o	5,25 (5,4o)	42
			65	5,6o (5,95)	29
			68	5,4o (5,62)	31
		o,o1	65		8
		o,o5	68	5,4o (5,62)	16
4.	Citraçonic acid	o,1	6o	5,35 (5,65)	62
5.	Dequaliniumchloride	o,o1	6o		54
			65		12
		o,o8	68		22
		o,o5			17
		o,oo5			12
6.	5-Diazo-uracil	o,o1	6o		99
		o,oo5			94
		o,oo2			89
		o,oo1			86
		o,ooo5			5o
		o,oo1	65		65
		o,ooo5			63
		o,oo8	68		99
		o,oo5			74
7.	Dimethyl-α,α'-dichlor-succinate	1 ml/2oo g	6o	5,25 (5,55)	83
		1 ml/3oo g	6o	5,5o (5,8o)	63
8.	Dimethylglyoxal	o,5 ml/1oo g	6o		97
		1 ml/1oo g	65		97
9.	D-Glutamic acid	o,1	6o	5,25 (5,4o)	43

+) pH was recorded only when the substance in question significantly reduced pH (pH of controls is given in brackets).

Tab.1o: continue

No.	Substance		Conc.%	T°C	pH+)		DVR %
1o.	1-Hexadecylpyridiniumbromide		o,o1	6o			55
			o,o1	65			93
			o,oo5				43
			o,o1	68			75
11.	4-Hexyl-resorcinol		o,o5	6o			4o
				68			17
12.	1-Hydroxy-2-methylnaphthalene-4-ammoniumchloride (Vitamin K_5)		o,o1	6o			2
				65			3
			o,o8	68			13
13.	Lactic acid		o,4 ml/1oo g	6o	5,o	(5,6)	92
			o,5 ml/1oo g	6o	4,8o	(5,6o)	9o
14.	Lauryl gallate		o,o2	55			17
				6o			16
			o,o5	6o			34
15.	Lysozyme	(a)	o,1	6o			35
		(b)	o,1	6o			79
		(a)	o,o5	6o			15
		(c)	o,o5	6o			38
		(b)	o,o5	6o			68
		(c)	o,o5	65			62
		(d)	o,1	68			25
			o,o5				25
		(a)	o,o8	68			7
16.	2-Methyl-1,4-naphthoquinone (Vitamin K_3)		o,o2	68			13
17.	Nordihydro-guaiaretic acid		o,o5	65			24
			o,o1	68			27

+) (a) = heated without preheatment;
(b) = kept at 3o°C for 2 hours, after a 16-hour-storage at 5°C;
(c) = heated after a 16-hour-storage at 5°C;
(d) = heated after a 22-hour-storage at 5°C.

Tab.1o: continue

No.	Substance	Conc.%	T°C	pH+)	DVR %
18.	Nordihydro-guaiaretic acid + 5-Diazo-uracil	o,o5 + o,oo3	65		6o
19.	Propyl gallate	o,o5	6o		5
			65		19
			7o		22
2o.	Sodium lauryl sulfate	o,o5	65		47
			7o		4
		o,o2	65		7
		o,o1	68		5
		o,oo5	6o		12
			65		25
21.	Sodium pyro-phosphate	o,4	68		27
22.	Sorbic acid	o,o8	68		16
		o,o5			23

Tab.11: Composition of emulsions (in parts of weight) as well as, results of measurments and temperature conductivity C^{++}). Initial temperature 2o°C, thermostat temperature 65°C

No.	Emulsifier	Fat	Emulsifier: Fat: Water	Temperature in °C after 15'	3o'	45'	6o'	75'	9o'	C^{++})
1.+)	Sodium caseinat	lard	1 : 5 : 5	22,7	3o,2	39,2	44,8	39,8	53,8	1,62
2.	Soybean protein	lard	I : 5 : 5	23,4	31,2	39,6	45,5	5o,4	53,9	1,88
3.+)	Glyceride	lard	1 : 5 : 5	21,4	25,1	29,8	37,7	43,9	49,9	o,78
4.+)	Sodium caseinat	sunflower-seed oil	1 : 5 : 5	23,o	31,2	39,8	46,7	51,6	55,o	1,78
5.	Soybean protein	sunflower-seed oil	1 : 5 : 5	23,5	31,o	39,1	45,5	5o,2	54,o	1,81
6.+)	Glyceride	sunflower-seed oil	1 : 5 : 5	22,6	27,5	36,1	43,9	48,7	52,8	1,o6
7.	Sodium caseinat	beef suet	1 : 5 : 5	22,9	29,6	37,1	41,8	47,6	51,3	1,59
8.	Soybean protein	beef suet	1 : 5 : 5	22,4	28,4	34,8	41,1	47,9	52,3	1,41
9.	Glyceride	beef suet	1 : 5 : 5	22,2	27,6	33,7	38,6	43,7	49,4	1,26
1o.	Sodium caseinat	coconut oil	1 : 5 : 5	22,8	29,6	36,8	43,4	48,4	51,6	1,61
11.	Soybean protein	coconut oil	1 : 5 : 5	22,8	29,9	37,8	43,7	48,7	52,3	1,68
12.	Glyceride	coconut oil	1 : 5 : 5	21,7	26,4	34,o	4o,8	46,8	5o,9	1,o9
13.	Sodium caseinat + lecithine	lard	1 : 5 : 5	22,7	29,5	37,6	44,3	49,8	53,7	1,61
14.	Glyceride + lecithine	lard	1 : 5 : 5	22,6	26,9	32,3	39,8	47,2	51,1	1,o1
15.	Sodium caseinat + Phosphate	lard	1 : 5 : 5	22,8	3o,3	38,o	44,4	49,3	52,7	1,78

No.	Emulsifier	Fat	Emulsifier: Fat: Water	Temperature in °C after 15'	3o'	45'	6o'	75'	9o'	C++)
16.	Glyceride + Phosphate	lard	1 : 5 : 5	22,7	26,8	33,1	39,9	45,3	49,9	o,97
17.	Soybean protein	lard	2 :1o :15	23,4	31,9	4o,o	46,8	51,6	54,6	2,o4
18.	Soybean protein	sunflower-seed oil	2 :1o :15	24,6	32,9	41,3	47,5	52,1	55,1	2,o5
19.	Soybean protein	beef suet	2 :1o :15	23,8	3o,6	37,1	43,3	49,3	53,1	1,65
2o.	Soybean protein	coconut oil	2 :1o :15	23,5	31,6	39,8	46,6	51,3	54,2	1,95
21.+)	Sodium caseinat	lard	3 :1o :2o	31,8	48,o	51,3	54,1	56,8	58,5	4,35
22.+)	Glyceride	lard	3 :1o :2o	22,2	26,8	34,6	41,9	48,5	52,5	o,98

+) Thermostate-Temperature 69°C

++) $C = 1o \frac{A}{B}$; A = t^{o} (15', 3o'), B = 65°C (69°C resp.) - t^{o} (15').

Tab.12: Composition of mixtures, results of measurements (No.1-8: average of three experiments with standard deviations, N.9. one experiment) and temperature conductivity C. Initiol temperature 2o°C, thermostat temperature 65°C

No.	Emulsion[2] (respectively 3o %) prepared with:	bacon %	meat %	Temperature in °C after: 15' $\bar{x}$	15' s	3o' $\bar{x}$	3o' s	45' $\bar{x}$	45' s	6o' $\bar{x}$	6o' s	75' $\bar{x}$	75' s	9o' $\bar{x}$	9o' s	C[3] $\bar{x}$	C[3] s
1.	NC[1])	7o	O	24,8	2,73	3o,6	3,67	38,2	3,94	45,6	3,54	51,o	3,14	55,o	2,76	1,46	o,35
2.	GL[1])	7o	O	23,6	1,28	29,4	1,o7	38,2	2,94	46,1	4,o9	51,5	3,84	55,6	3,76	1,39	o,18
3.	NC	45	25	21,2	o,2o	24,7	1,16	31,8	3,97	41,2	3,94	48,6	3,29	54,5	2,41	o,79	o,23
4.	GL	45	25	21,o	o,17	23,9	o,62	3o,2	1,19	38,4	o,95	45,8	o,95	51,1	1,41	o,66	o,11
5.	NC	25	45	22,2	o,26	28,2	o,96	37,5	1,56	45,7	1,85	51,8	1,89	55,6	1,68	1,4o	o,2o
6.	GL	25	45	21,3	o,1o	26,5	1,oo	36,4	2,48	44,2	3,14	5o,o	2,97	54,o	2,98	1,2o	o,24
7.	NC	O	7o	32,o	o,76	43,2	o,85	51,o	o,81	55,6	o,95	58,4	o,95	6o,1	1,o5	3,41	o,11
8.	GL	O	7o	33,o	o,1o	43,2	o,67	5o,6	1,74	55,3	1,13	58,3	o,92	6o,2	o,62	3,23	o,19
9.	--	1oo	--	2o,6	--	22,5	--	25,6	--	32,6	--	44,7	--	--	--	--	--

[1]) NC = Na-caseinate; GL = Glycerid emulsifier

[2]) Emulsifier:sunflower seed oil:water = 1:5:5

[3]) See Tab.11

Fig1: Heat Transfer in Emulsions Prepared with Sodium Caseinate, Soy Bean Protein, Glyceride or Minced Fat Tissue (Bacon).

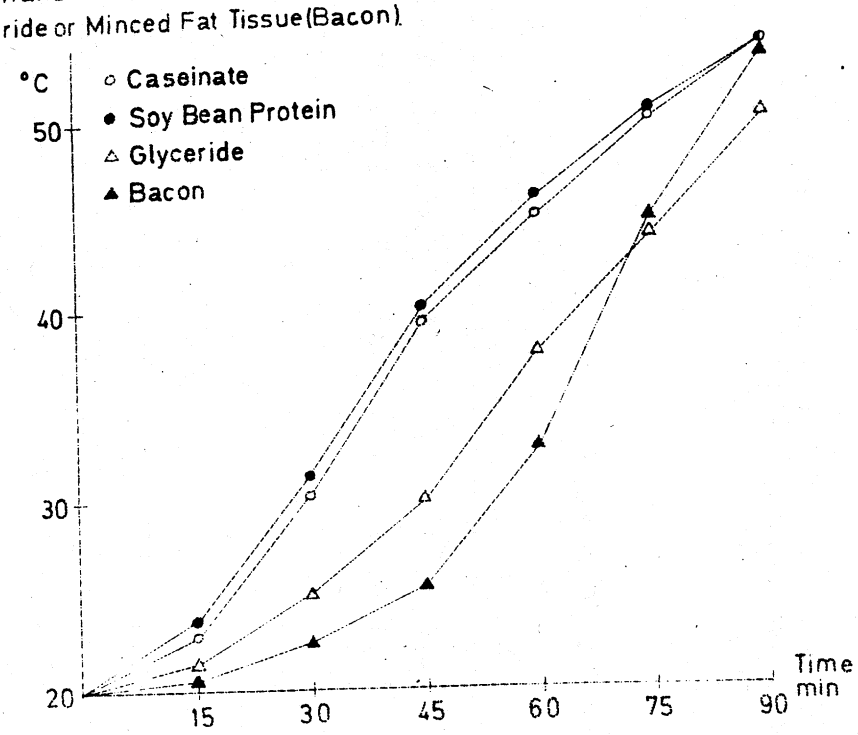
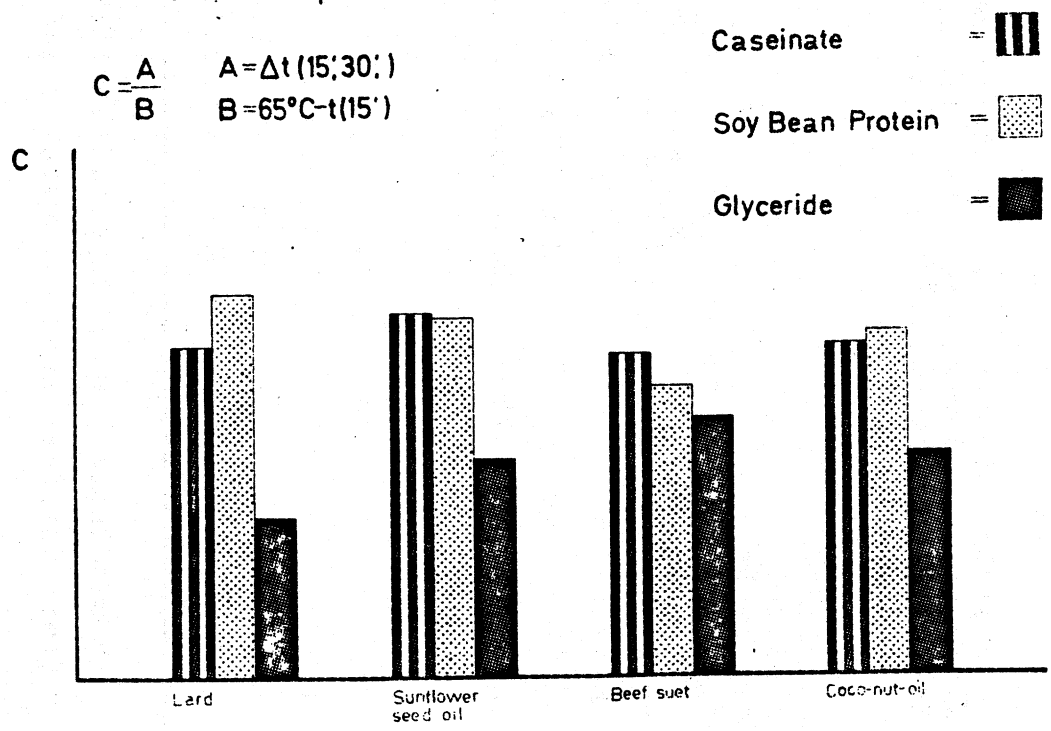


Fig.2: Influence of the Kind of Emulsifier on the Heat Penetration Factor C in Water-Fat-Emulsions Prepared with Different Fats.

$C = \frac{A}{B}$ $A = \Delta t\,(15';30')$ $B = 65°C - t(15')$



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